

MODIS

Science Data Processing Software

Version 1 Requirements Specification



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Prepared By:

Jenny Glenn, SAIC/General Sciences Corporation
SDST Systems Analyst

Date

Reviewed By:

Dr. Wayne Esaias, GSFC/Code 971
MODIS STM Oceans Group Leader

Date

Dr. Robert Evans, University of Miami
MODIS STM Oceans Data Systems

Date

Dr. Al Fleig, University of Maryland
Data System Scientist

Date

Dr. Chris Justice, University of Maryland
MODIS STM Land Group Leader

Date

Dr. Youram Kaufman, GSFC/Code 913
MODIS STM Atmospheres Group Leader

Date

Barbara Putney, GSFC/Code 920
MODIS Systems Engineer

Date

Reviewed By:

Laurie Schneider, SAIC/General Sciences Corporation
SDST R&QA Manager

Date

Dr. Bruce Guenther, GSFC/Code 925
MODIS MCST Task Leader

Date

Tom Piper, SAIC/General Sciences Corporation
MODIS SDST Task Leader

Date

Approved By:

Edward Masuoka, GSFC/Code 920.2
MODIS SDST Manager

Date

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Version 1 Requirements Specification

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1. INTRODUCTION

1.1 Purpose

This document is the requirements specification for the Version 1 (V1) Release of the Moderate Resolution Imaging Spectroradiometer (MODIS) Science Data Processing Software (SDP S/W) system. The V1 Release shall be integrated in the MODIS Team Leader Computing Facility (TLCF) at Goddard Space Flight Center (GSFC) and migrated to the EROS Data Center (EDC) Distributed Active Archive Center (DAAC) and the GSFC DAAC. The Team Leader Working Agreement (TLWA) serves as the parent document for this requirements specification. As defined by the TLWA, the programs in the V1 delivery shall demonstrate all major functional capabilities and a complete operator interface, including the generation of all needed messages using standard error and message services. V1 shall require realistic computational resources, near those of Version 2 (V2), the launch-ready system.

1.2 Scope

This document identifies the requirements on all of the software elements comprising the MODIS V1 Release of the SDP S/W. The major software elements provided by the Science Data Support Team (SDST) and the MODIS Characterization Support Team (MCST) include:

- Level 1A (L1A) and Geolocation Processing Software
- Level 1B (L1B) Processing Software
- Product Generation Executable (PGE) scripts
- MODIS-Application Program Interface (M-API) utilities

The major software elements provided by the Science Team Members (STM) include:

- Level 2 (L2), Level 3 (L3), and Level 4 (L4) software processes
- Gridding and binning utilities
- Cloud masks
- Production Rules for PGE initiation

1.3 Version 1 Goals

The overall goals for the V1 Release of the MODIS SDP S/W are:

- Demonstrate that each Science Team software developer has delivered working code that ingests simulated MODIS instrument data, or data derived from simulated MODIS instrument data.
- Demonstrate that working code which generates all at-launch products has been delivered.
- Employ the full set of ancillary data sets required by the STM-supplied software processes using the formats/resolutions required by those software processes.
- Demonstrate incorporation of the necessary logic to ingest, evaluate, and generate the appropriate Quality Assurance (QA) flags for each MODIS product.
- Baseline the Hierarchical Data Format (HDF) file specification for each MODIS at-launch product.
- Demonstrate use by MODIS Science Software of the HDF-Earth Observing System (EOS) constructs and utilities.
- Identify the spatial and temporal dependencies between STM-supplied software processes needed to integrate the processes into the expected at-launch threads of execution and to provide the necessary Level 1 (L1) test data sets to test these dependencies.
- Prototype multigranule, multiprocessing execution.
- Exercise the scheduling software chosen for the DAACs to verify that it meets MODIS's requirements and functions properly in the MODIS processing context.
- Test the STM-supplied software and processing threads under both normal operation and exception-handling scenarios.
- Provide accurate estimates of the computing resource requirements and output volumes of at-launch MODIS products based on actual software timing.
- Identify algorithms which exceed their allocated computing and/or volume resources and begin to study them for more efficient solutions.
- Prototype on operation system that is able to mimic the DAAC operation to include day/night and land/ocean capabilities.
- Provide Science Computing Facility (SCF) capability to run and debug their algorithms.

1.4 Content and Structure

This document's structure was derived from NASA-STD-2100-91 and is organized into the following sections:

- Section 1 provides the background and introduction to this document.
- Section 2 details the system-level requirements for V1.

- Section 3 details the process-specific requirements.
- Section 4 identifies product-specific requirements.
- Section 5 identifies PGE requirements.
- Section 6 identifies testing requirements.
- Section 7 identifies operational requirements.
- Section 8 identifies the acronyms and abbreviations.

1.5 Relevant Documents

The following documents serve to provide information relevant to the MODIS V1 Requirements Specification document:

- MODIS Software Management Plan; October 24, 1995; SDST-002.
- MODIS Data Management Plan; October 25, 1995; SDST-006.
- MODIS Operations Concept Document-Version 1, SDST, August 1993.
- MODIS Software Development Standards and Guidelines, Version 1; SDST-022 (Change 1); October 25, 1995.
- M-API User's Guide, Version 1.1; P600-CD-001-002; June 19, 1995.
- MODIS Product Volumes and Process Load Estimates; SDST-009; August 11, 1995.
- MODIS Version 1 Test Plan; TBD; SDST-060.
- MODIS Version 1 Processing Files Description Document; TBD; SDST-061.
- Science Software Integration and Test Procedures for the MODIS Instrument at the GSFC DAAC; September 1995; SDST-017.
- Data Production Software (DPS) and Science Computing Facility (SCF) Standards and Guidelines; January 1994.
- EOS Reference Handbook.
- ICD Between EOSDIS Core System (ECS) and SCF-Prelim. (209-CD-005-001), 1/95
- Science User's Guide and Operations Procedure Handbook for the EOS Core System (ECS) Project, Part 4: Software Developer's Guide to Preparation, Delivery, Integration, and Test with the ECS; 205-CD-002-002; Final, August 1995.
- SDP Toolkit User's Guide for the ECS Project; August 1995; DID 333-CD-003-002.
- Science Processing Support Office (SPSO) Product Database.
- Team Leader Working Agreement for MODIS Between EOS AM & PM Projects GSFC and the MODIS Science Team Leader; GSFC 421-12-14-02; April 21, 1994.
- Science Data Processing Segment (SDPS) Database Design and Database Schema Specification for the ECS Project", DID 311-CD-002-002.

Figure 1-1 shows the documentation tree for the documents developed (or to be developed) by the SDST for the MODIS Team Leader. This figure shows the relationship between the TLWA and MODIS Project documentation.

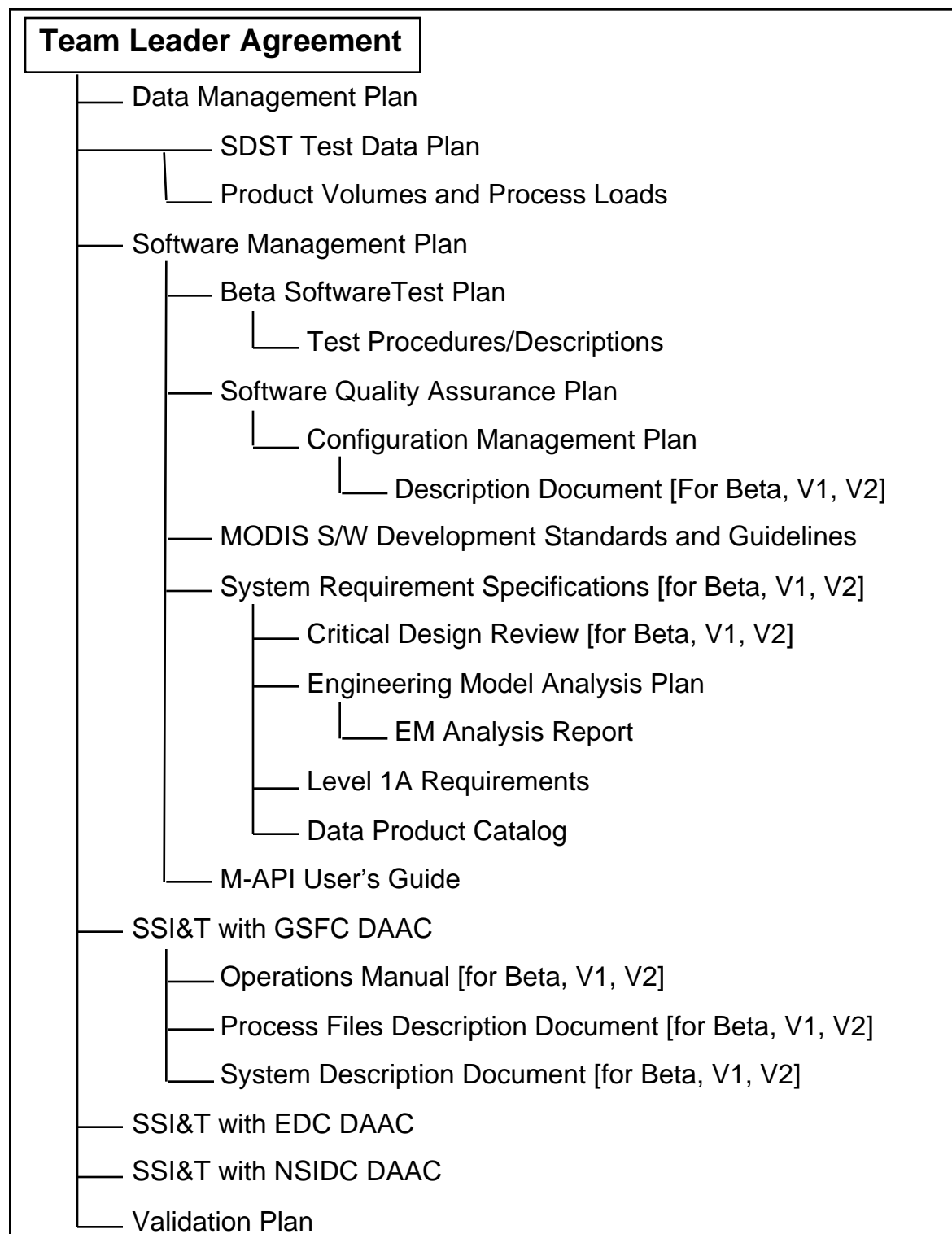


Figure 1-1 MODIS Documentation Tree

2. VERSION 1 SYSTEM-LEVEL REQUIREMENTS

2.1 External Constraints

This section describes the assumptions and dependencies affecting the MODIS SDP S/W for the Version 1 Release.

- The MODIS Geolocation Computer Software Configuration Item (CSCI MOD_PR03) depends on ECS to provide the following capabilities implemented in SDP Toolkit routines:
 - Time and coordinate transformations
 - Access to solar system object positions
 - Access to spacecraft information for a requested time, including orbit and attitude data, orbit numbers, and telemetry from the thermal and power systems
 - Values of mathematical and physical constants
 - Access to ECS-provided elevation data
- National Center for Supercomputing Applications (NCSA) HDF does not currently support running on the Silicon Graphics Inc. (SGI) Power Challenge in 64-bit mode. SDST is relying on either NCSA or ECS to upgrade this software by March 1, 1996.
- The science teams shall consider using Data Assimilation Office (DAO) products instead of the National Meteorological Center (NMC) products, where possible.

2.2 Configuration Control

- 2.2-1 When delivered to each DAAC, the initial release of the integrated software system shall be identified as the MODIS SDP S/W V1 Release 1.0.
- 2.2-2 A software process shall be available for integration into the MODIS SDP S/W V1 Release after it has been accepted into the SDST Configuration Management Officer's (CMO) baselined library directory.
- 2.2-3 A software process shall be placed in the SDST CMOs baselined library after it has passed the Code Acceptance Process detailed in the MODIS Software Management Plan (SMP).
- 2.2-4 The SDST CMO shall employ ClearCase, produced by Atria Software, Inc., as the configuration management tool for maintaining version control of the source code, binary files, executables, test suites, and libraries used in creating the V1 Release 1.0 and subsequent releases.
- 2.2-5 Configuration Management (CM) of the released software in the TLCF, and during the infusion process in the DAACs, shall be the responsibility of the MODIS SDST. The CM of the released software after it has been accepted for production shall be the responsibility of the DAAC.

- 2.2-6 The process for carrying patches or delta deliveries of the MODIS SDP S/W to a DAAC shall be specified by the applicable Science Software Integration and Test Procedures (SSI&T) document.

2.3 Interface Requirements

- 2.3-1 Each software process within the MODIS V1 SDP S/W system shall employ the Earth Science Data and Information System (ESDIS)-supplied Science Data Production Toolkit (SDPTK) Version 6 (V6) mandatory functions to access the DAAC production environment and services. The mandatory functions include generic file Input/Output (I/O), metadata, error message transaction, process control, ancillary data access, spacecraft ephemeris and attitude, and time and date transformations (DID 333-CD-003-002, August 1995, Section 4.1).
- 2.3-2 Each software developer, with the help of the Science Software Transfer Group (SSTG), shall provide an HDF file description for the achievable MODIS product(s) produced by their software. This specification shall describe the structure and format of the files down to the bit level. This specification shall be provided to the SDST CMO no later than the delivery of the software to the SDST SSTG.
- 2.3-3 Each software developer, with the help of the SSTG, shall provide an Interface Control Document (ICD) for each software process they develop. The ICD shall describe the size and purpose of each of the input and output files used/produced by the software. If MODIS L1B data is ingested by the process, the bands used shall be identified. In the case where MODIS Standard Products are created, the SPSO output parameters for the product shall be identified. The ICD shall be provided to the SDST CMO no later than the delivery of the software to the SDST SSTG and shall be updated as necessary with each subsequent delivery.
- 2.3-4 Each software developer shall notify the appropriate SSTG discipline lead via e-mail when they become aware of a 25 percent or more increase or decrease in either the processing load or data volume for their product(s) for those products that require more than 75 MFLOPS. The reference values for processing load and data volume shall be taken as the values in the MODIS Product Volumes and Process Load Estimates document. The e-mail message shall indicate the estimate of the new values, the underlying change in the algorithm leading to the change, and when the code implementing the change will be delivered to the SDST SSTG.
- 2.3-5 The numbering scheme for the Process Control File (PCF) logical numbers used by the software processes to obtain data from the SDPTK shall follow a consistent convention defined by the SDST, and shall not conflict with the range of logical numbers reserved for use by the Toolkit routines (10,000 - 10,999).
- 2.3-6 The numbering scheme for the Status Message Facility (SMF) seed numbering assignments used by the software processes to log error messages to the SDPTK shall follow a consistent convention defined by the SDST, within the range of values assigned by ECS to MODIS (35,000 - 39,999).

3. VERSION 1 SOFTWARE PROCESS REQUIREMENTS

3.1 Process Definitions

- 3.1-1 A software process is defined as any element of executable software listed in Table 3-1.
- 3.1-2 The software processes listed in Table 3-1 are the complete set of processes that shall be incorporated in the V1 Release.
- 3.2-3 The output of the V1 software processes shall be consistent with the MODIS Data Product Catalog, which is available on-line at Universal Resource Locator (URL) <http://modarch.gsfc.nasa.gov/MODIS/DATAPROD/dataprodcatalog.html>.

3.2 Process Interface Requirements

- 3.2-1 Each process in the V1 release shall be capable of being ported to and running on an SGI platform under the IRIX 6.1 or higher operating system running in 64-bit mode.
- 3.2-2 Processes requiring HDF utilities to produce data files shall use HDF Version 4.0.

3.3 Process Coding Standards

- 3.3-1 Each software process shall be coded according to the standards specified in the most recent baselined version of the MODIS Software Development Standards and Guidelines, SDST-022.

3.4 Process Reliability Standards

- 3.4-1 The MODIS processing software shall trap and properly process all exceptions that may produce an abort condition and report all such events to the message log files.
- 3.4-2 The MODIS processing software shall terminate gracefully upon detection of a non-recoverable error condition.
- 3.4-3 The test phases for the V1 Release shall be defined in the MODIS Version 1 System Test Plan; SDST-060.
- 3.4-4 Each software process in the MODIS SDP S/W V1 system shall demonstrate the ability to process input test data sets with the following attributes:
 - 3.4-4.1 Missing data, including missing pixels, missing bands, and/or missing scans marked by the appropriate fill data.
 - 3.4-4.2 Redundant data, including repeated packets at Level 0 and repeated scans at L1 and L2.

- 3.4-4.3 Noisy or corrupted data as indicated by QA flags also located within the file.
- 3.4-4.4 Time transitions, including Greenwich Meridian crossing, International Data Line crossing, leap year, beginning of the year, beginning of the millennium, and/or initial turn-on not on a granule boundary.
- 3.4-4.5 Terminator crossings.
- 3.4-4.6 Night mode data.
- 3.4-4.7 Missing input MODIS Product files, ancillary files, and Look-up Tables (LUT).
- 3.4-4.8 Wrong format input files.

Table 3-1 MODIS Software Process Definition

4. SCIENCE DATA PROCESSING SOFTWARE PRODUCT REQUIREMENTS

4.1 Product Definitions

- 4.1-1 A MODIS product shall be defined as any data file identified with a Product ID in Table 3-1.
- 4.1-2 The definition of the level of a given product shall adhere to Table 4-1, MODIS Data Level Definitions.
- 4.1-3 One or more MODIS standard products defined in Table 3-1 shall be stored in HDF-EOS file structures.
- 4.1-4 No HDF product file shall exceed two gigabytes in size for the V1 Release.
- 4.1-5 All bit data within a product (QA information, masks, flags, etc.) shall be designed to fall within byte boundaries.

Table 4-1 MODIS Data Level Definitions

Data Level	Data Definition
Level 0	Instrument data at original resolution, time ordered restored, with duplicate packets removed.
L1A	Level 0 data which are reformatted with calibration data and other ancillary data included. Geolocation information for each 1 km spatial element of the reformatted swath data will be stored as a separate product.
L1B	L1A data to which the radiometric calibration algorithms have been applied to produce radiances or irradiances.
L2	Geophysical parameter data retrieved from the L1B data by application of geophysical parameter algorithms.
L3	Earth-gridded geophysical parameter data, which have been averaged, gridded, or otherwise rectified or composited in time and space.
L4	Model output or results of analysis from lower level data, for example variables derived from multiple measurements.

4.2 Product File Naming Conventions

Product file naming conventions are necessary to allow users of MODIS archived products to search and retrieve data file lists from ECS without having to open each file and read extensive amounts of metadata in order to understand the contents.

- 4.2-1 The SDST shall define a consistent naming convention of the MODIS Product Files.

4.3 Metadata Requirements

- 4.3-1 Each MODIS Standard Product (as defined in Table 3-1) shall contain ECS core metadata as specified in DID 311.
- 4.3-2 The fields making up the core metadata shall have the same definition and range of values across all MODIS data products.
- 4.3-3 Each MODIS Standard Product shall contain product-specific metadata.
- 4.3-4 The fields making up product-specific metadata shall have fields that are specific to a given data product.
- 4.3-5 The information comprising the Metadata Configuration File (MCF) shall be provided by each product's developer.

4.4 Product Gridding, Tiling, and Geolocation

4.4.1 Product Gridding Requirements

- 4.4.1-1 The MODIS L3 and L4 products shall be produced on a Binned Sinusoidal grid, which is an equal area grid.
- 4.4.1-2 A spherical shape shall be assumed for the Earth when making a sinusoidal projection.
- 4.4.1-3 The spatial starting points for the grid shall be defined such that vertically (latitudinal) the bottom of the first row of cells in the Northern hemisphere will touch the equator and horizontally (meridional) the left edge of the first cell on the left at the equator will be at 180 degrees West longitude.
- 4.4.1-4 The allowed grid resolutions for climatological modeling shall use an equal angle grid at 1.0 degree (111 km), 0.5 degree (57 km), and/or 0.25 degree (28.5 km) resolution.

4.4.2 Tiling Requirements

To be determined.

4.4.3 Geolocation System-Level Spatial Requirements

- 4.4.3-1 The MODIS geolocation process shall generate Earth locations for each 1 km spatial element.
- 4.4.3-2 The Earth locations shall consist of geodetic coordinates (latitude, longitude, and height), satellite vectors (zenith, azimuth, and range), solar vectors (zenith and azimuth), and quality flags.

- 4.4.3-3 The MODIS geolocation process shall have an absolute Earth location accuracy of 0.1 (2 sigma) Instantaneous Field-Of-View (IFOV) for the nominal 1 km resolution bands, with respect to the World Geodetic System 84 (WGS84) reference frame.
- 4.4.3-4 The MODIS geolocation process shall compute the azimuth and elevation of the Sun relative to the plane containing the surface of the solar diffuser and relative to the scan plan as defined in MODIS centered coordinates.

4.5 QA Flag Requirements

- 4.5-1 Each MODIS Standard Product (as defined in Table 3-1) shall contain appropriate QA flags which shall indicate the quality of the input data and the product fields.
- 4.5-2 QA flags shall be included for the granule as a whole and for each scan, spatial element, bin or tile, as appropriate for the product level.

5. VERSION 1 OPERATIONS REQUIREMENTS

5.1 Operations Definitions and Context

The overall context for the V1 Release of the MODIS SDP S/W is shown in Figure 5-1. As illustrated, certain parts are only produced at certain DAACs.

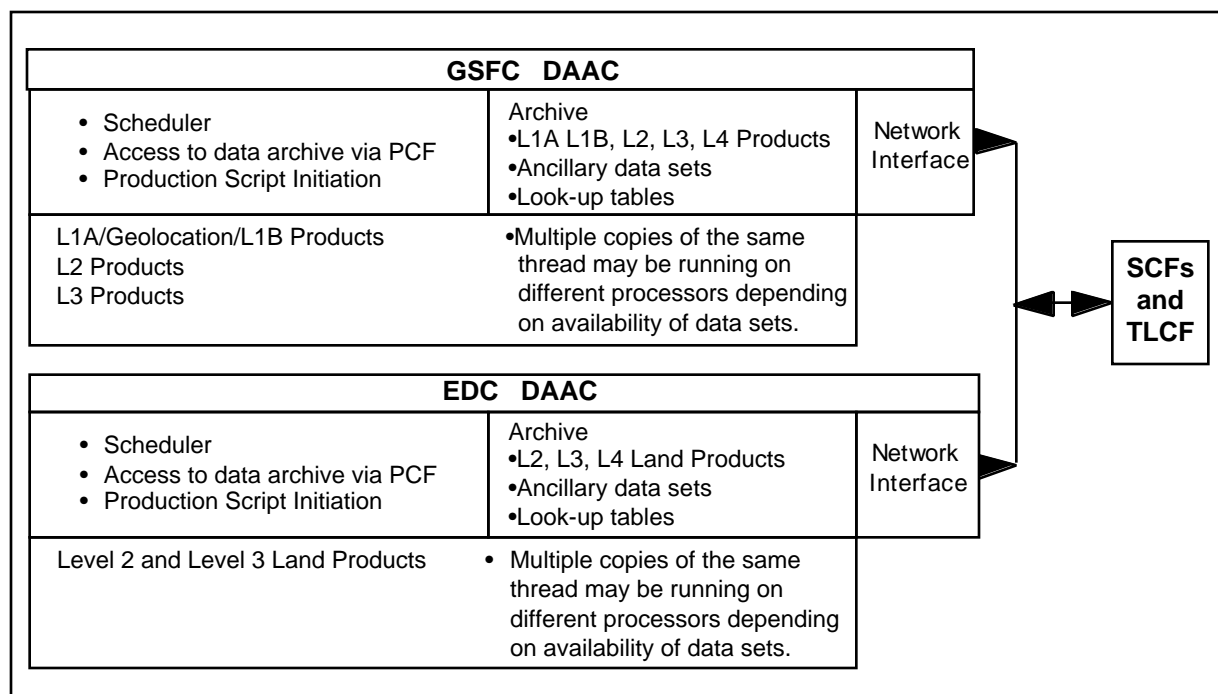


Figure 5-1 MODIS SDP S/W Context

The sequence of events shown in Figure 6-2 applies to a given MODIS PGE. The GSFC DAAC is shown for illustrative purposes the same scenario operates in the EDC DAAC.

- 5.1-1 The operations activities associated with the delivery of V1 to the GSFC DAAC shall be defined in SSI&T procedures for the MODIS Instrument at the GSFC DAAC, SDST-017.
- 5.1-2 The V1 Release shall integrate all software processes available to the SDST software integration team into a SDP S/W system that executes all processes in the MODIS TLCF, and executes the processes in the GSFC DAAC, EDC DAAC, and the National Snow and Ice Data Center (NSIDC) DAAC (if available in Release A) as specified in Table 3-1.

5.2 Product Generation Executive Requirements

5.2-1 A PGE shall execute MODIS software processes within the ECS environment.

5.2-2 The PGE shall include the option of running in a 'debug' mode, where the debug mode provides additional execution and/or error messaging information to facilitate troubleshooting.

6. REQUIREMENTS TRACEABILITY MATRIX

To be supplied.

APPENDIX A: ACRONYMS AND ABBREVIATIONS

CM	Configuration Management
CMO	Configuration Management Officer
CSCI	Computer Software Configuration Item
DAAC	Distributed Active Archive Center
DAO	Data Assimilation Office
ECS	EOSDIS Core System
EDC	EROS Data Center
EOS	Earth Observing System
ESDIS	Earth Science Data and Information System
GSFC	Goddard Space Flight Center
HDF	Hierarchical Data Format
ICD	Interface Control Document
IFOV	Instantaneous Field-Of-View
L1	Level 1
L1A	Level 1A
L1B	Level 1B
L2	Level 2
L3	Level 3
L4	Level 4
LUT	Look-Up Table
M-API	MODIS Application Programming Interface
MCF	Metadata Configuration File
MCST	MODIS Characterization Support Team
MODIS	Moderate Resolution Imaging Spectroradiometer
NCSA	National Center for Supercomputing Applications
NMC	National Meteorological Center
NSIDC	National Snow and Ice Data Center
PCF	Process Control File
PGE	Product Generation Executive
QA	Quality Assurance
SCF	Science Computing Facility
SDP S/W	Science Data Production Software
SDPS	Science Data Processing Segment
SDPTK	Science Data Production Toolkit
SDS	Software Development Standards
SDST	Science Data Support Team
SGI	Silicon Graphics Inc.
SMF	Status Message Facility
SMP	Software Management Plan

SPSO	Science Processing Support Office
SSI&T	Science Software Integration and Test
SSTG	Science Software Transfer Group
STM	Science Team Member
TLCF	Team Leader Computing Facility
TLWA	Team Leader Working Agreement
URL	Universal Resource Locator
V1	Version 1
V2	Version 2
V6	Version 6
WGS84	World Geodetic System 84

APPENDIX B: MODIS SDP S/W VERSION 1 RELEASE BUBBLE CHARTS

